Testing of a Cellphone-based Cosmic-ray Detector Network

VERONICA HOYO

Haverford College 370 Lancaster Avenue Haverford, PA 19041

Abstract

The purpose of this project was to measure cosmic rays using a phone cameras and the Distributed Electronic Cosmic-Ray Observatory (DECO) application as a low-cost monitoring network. DECO is able to detect cosmic rays using the Charge Coupled Devices (CCD) on the camera on a phone. To test if the application is reliably measuring cosmic-ray events, the phones were set to record their event rates at different tilt angles relative to the plane of the sky and compared against a calibrated Quarknet detector. The two phones used in this study showed a similar angular response with their event rates, although these differed from the Quarknet detector. Issues of false triggering on the CCDs from thermal flare are considered in this study.

Introduction

Cosmic rays are energetic subatomic particles which impact the Earth from an extraterrestrial source. Most of these particles do not directly reach the Earth's surface, but are indirectly detected by their secondary particles produced in collisions in the upper atmosphere (Fig 7). These particles are studied for various reasons, from using relatively low-energy rays to monitor solar flares to using the highest energy particles are probes of physics beyond the Standard Model. As flux drops quickly with energy it becomes necessary to create large detector arrays, which has provided the motivation to use the near-ubiquitous hardware found in phone to make a large distributed detector network.

Apparatus

For the experiment one Quarknet cosmic-ray detector was used along with two Wildfire cell phones running Android with DECO installed. All collected was recorded manually into a spreadsheet for later analysis. The Quarknet detector software would run on a Windows-based pc, logging each event with a GPS time stamp. The DECO-enabled phones would log data internally and on a remote server for later image recovery of potential events (Figs 1 and 5.

Figure 1- An example event

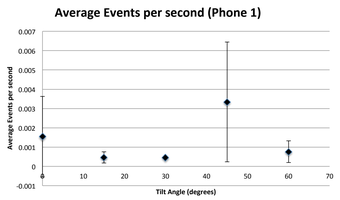

Figure 2 - Events per second vs tilt angle (Phone 1)

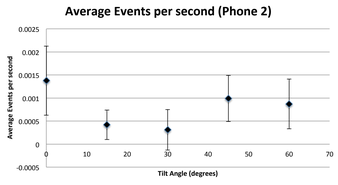

Figure 3 - Events per second vs tilt angle (Phone 2)

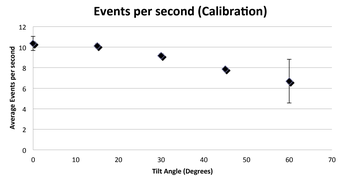

Figure 4 - Events per second vs tilt angle (Quarknet)

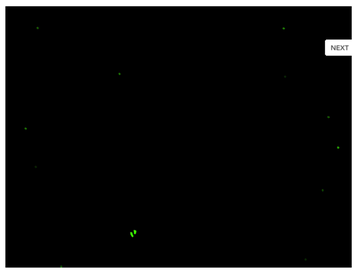

Figure 5- An example of noise and signal

Figure 6- Experimental set-up

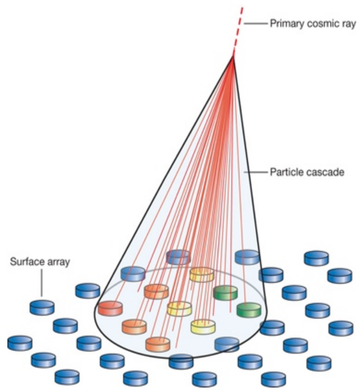

Figure 7- An example of an extensive air-shower With ground-based detectors.

Experimental Set-up

The cell phones and Quarknet detector are arranged with their planes parallel at a set angle ranging from zero to sixty degrees in fifteen degree increments (Fig 6). The average run time for both types of detectors was approximately a day, with multiple runs done at each angle. The mean and standard deviation of event rates versus the tilt angle were calculated for the phones from the day long exposures, while the Quarknet detector mean and standard deviation was taken from doing ten exposures of five minutes duration. This could be done as the Quarknet detector, with a much larger detector area than the phone CCDs, had an event rate of approximately four orders of magnitude larger than either phone.

Analysis

With both phones there is a similar relationship between tilt angle and event rate, with a decrease in the event rate from zero to thirty degrees tilt followed by a rise up to sixty degrees of tilt (Figs 2 and 3). This pattern runs counter to the relationship between tilt angle and event rate for the Quarknet detector, which shows a consistent decline in event rate from zero to sixty degrees of tilt (Fig 4). This difference may be a result of the phone CCD passing through more of the heat produced by the battery as tilt angle is increased, which can be detected by the CCDs as an image. Understanding the source of this difference will be one goal of future research.

References

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